Sacramento San Joaquin Delta

Levee Decision Analysis Model (LDAM)

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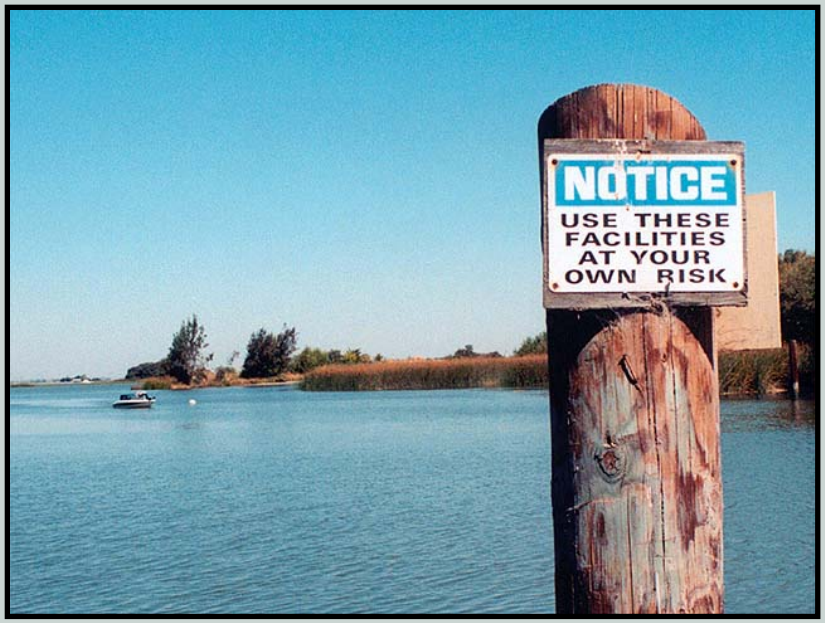
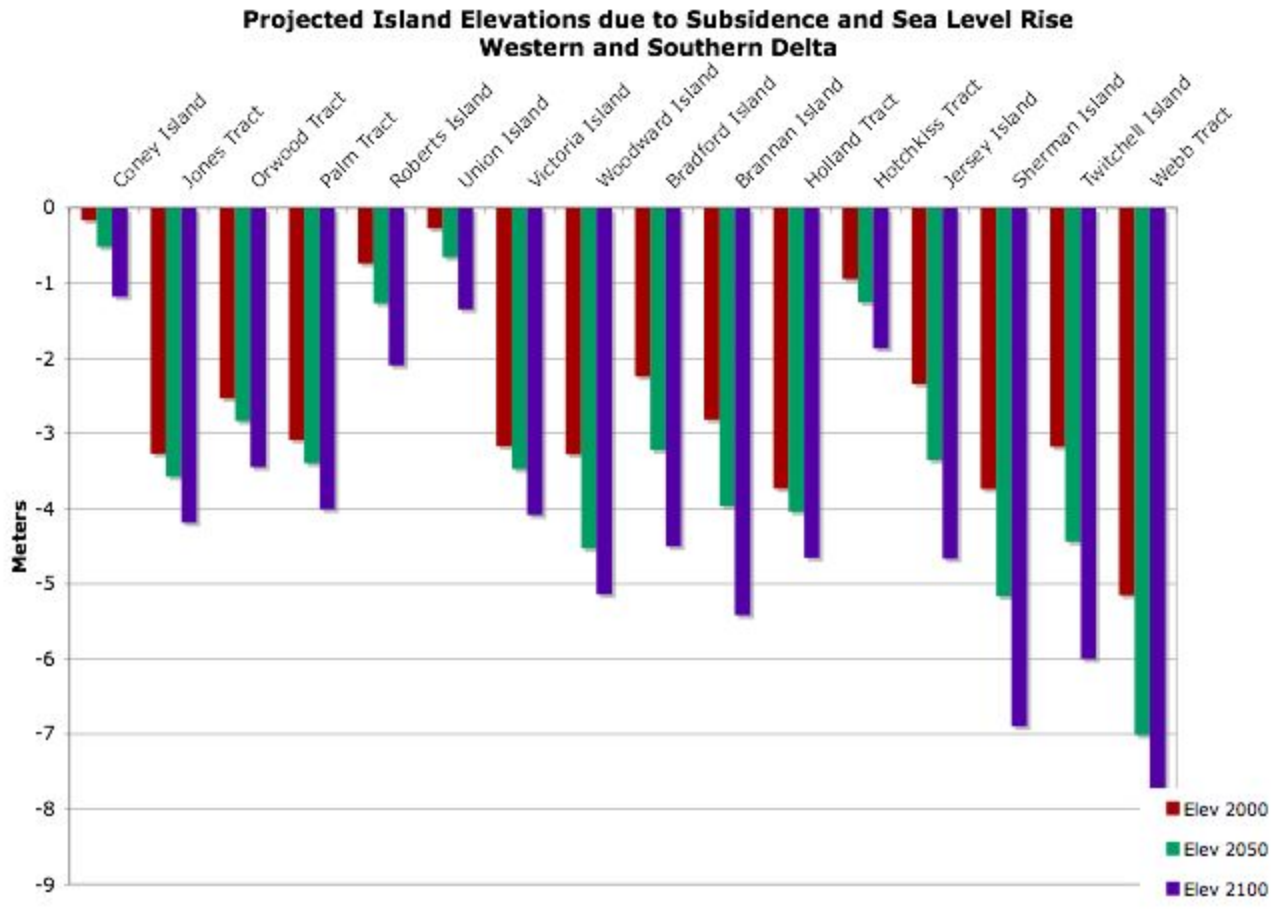
Inevitable Change in the Delta

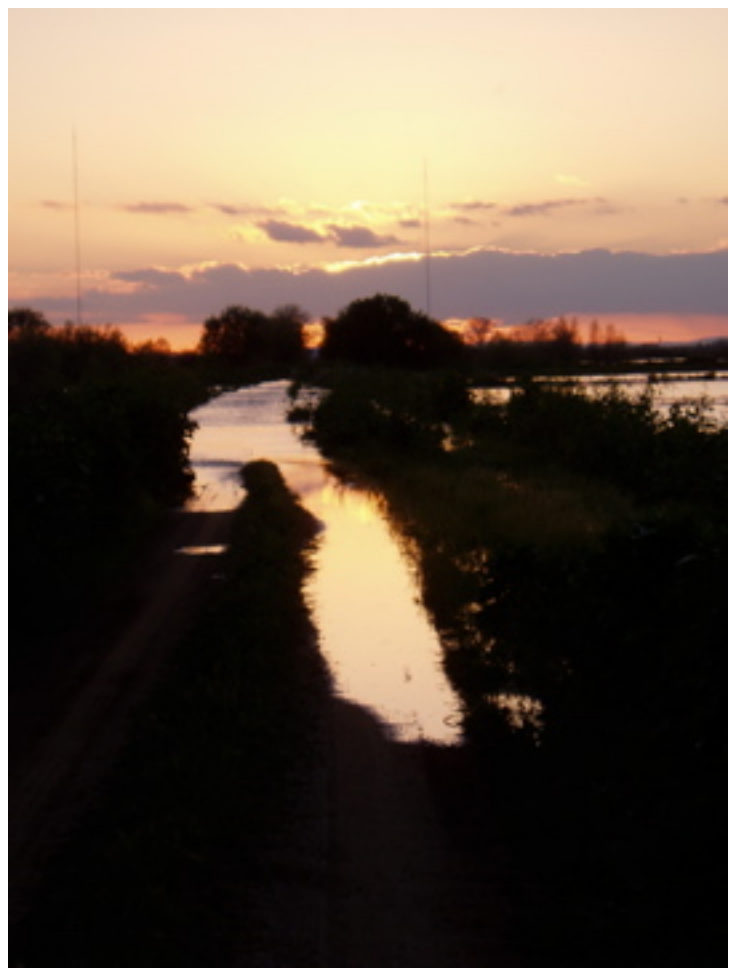
Four Physical Drivers:

- Sea Level Rise
- Subsidence
- Changing Inflows
- Seismic Activity

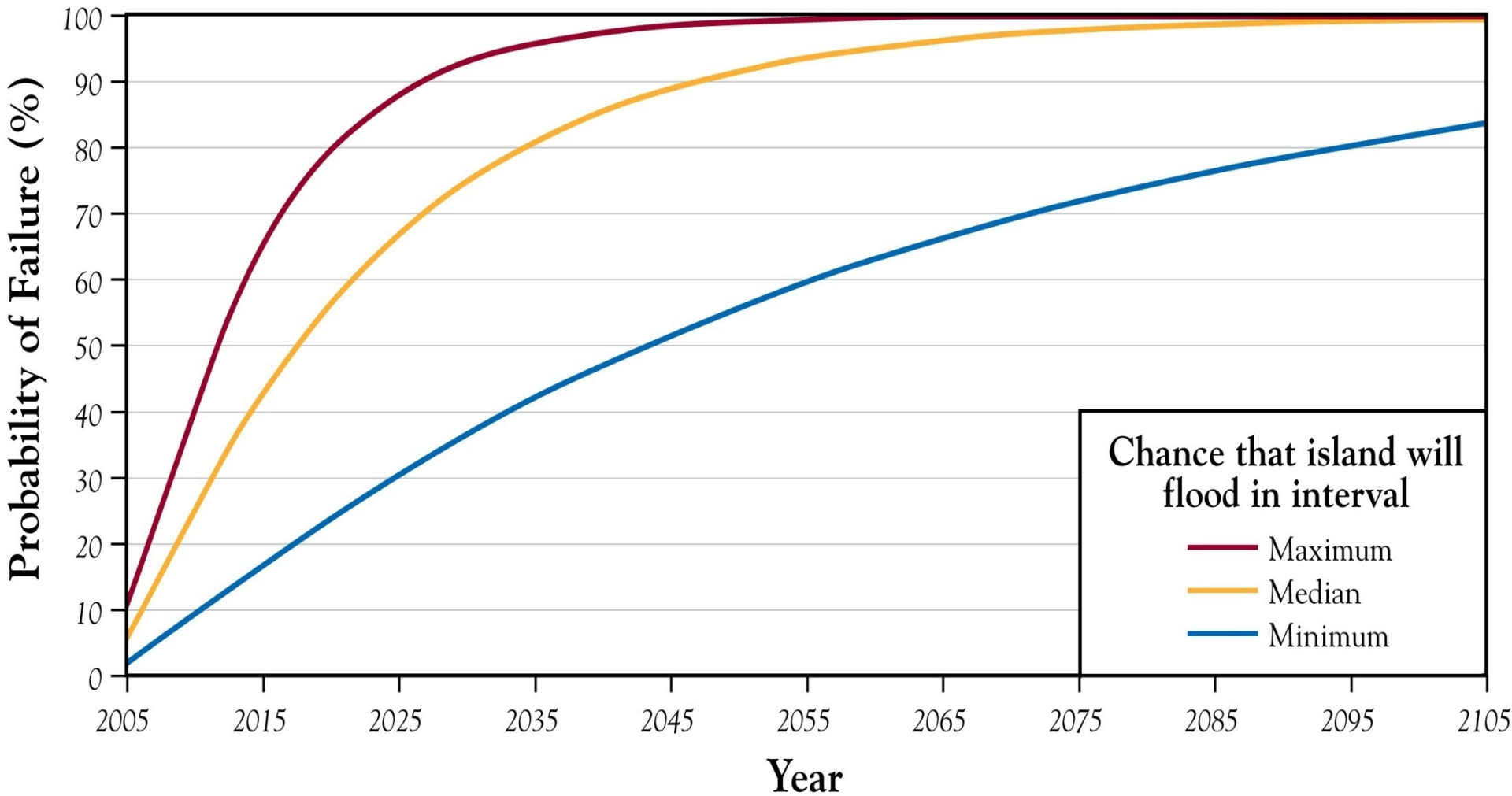



Projected Island Elevations due to Subsidence and Sea Level Rise
Western and Southern Delta
Coney Island
Jones Tract
Orwood Tract
Palm Tract
Roberts Island
Union Island
Victoria Island
Woodward Island
Bradford Island
Brannan Island
Holland Tract
Hotchkiss Tract
Jersey Island
Sherman Island
Twitchell Island
Webb Tract
Meters
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
Elev 2000
Elev 2050
Elev 2100

Changing Inflows



Probability of Failure Over the Next 100 Years



Inevitable Change in the Delta

Financial Drivers:

Competing Public Interests

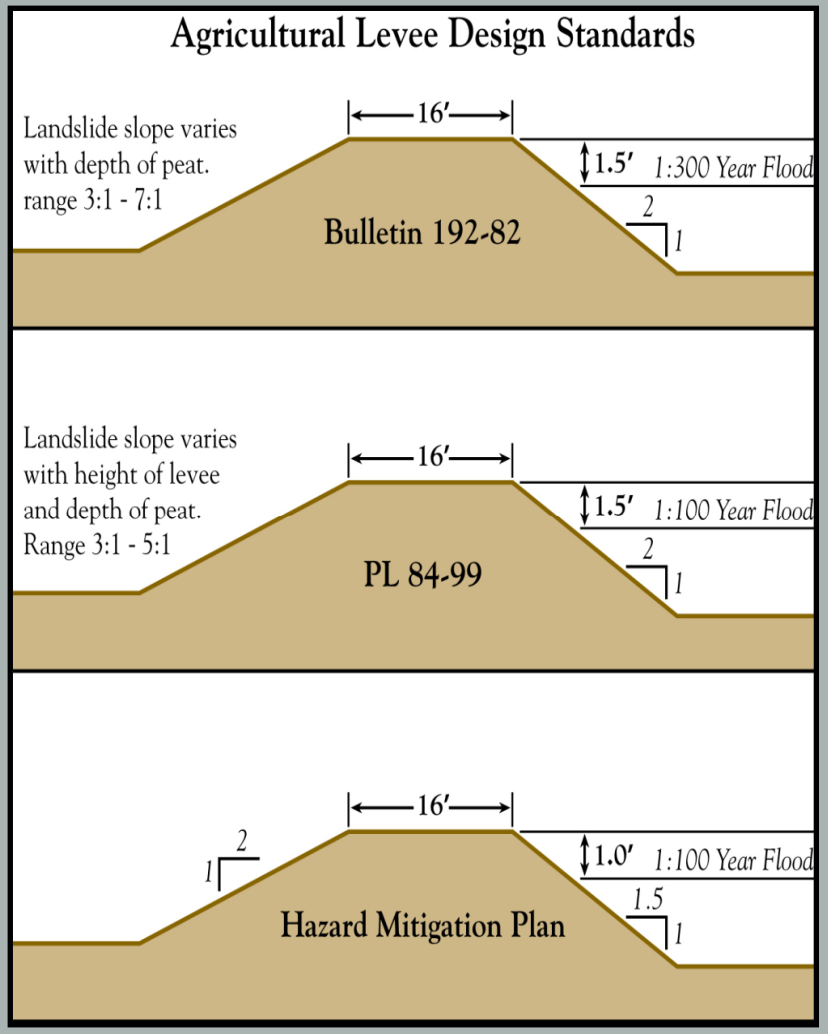
Limited Private and Public Funding Available

The Question

How should the state optimally prioritize levee upgrade and repair efforts in the Delta?

Alternative Levee Policy:

Selective Upgrades and Repairs for **Individual** Islands

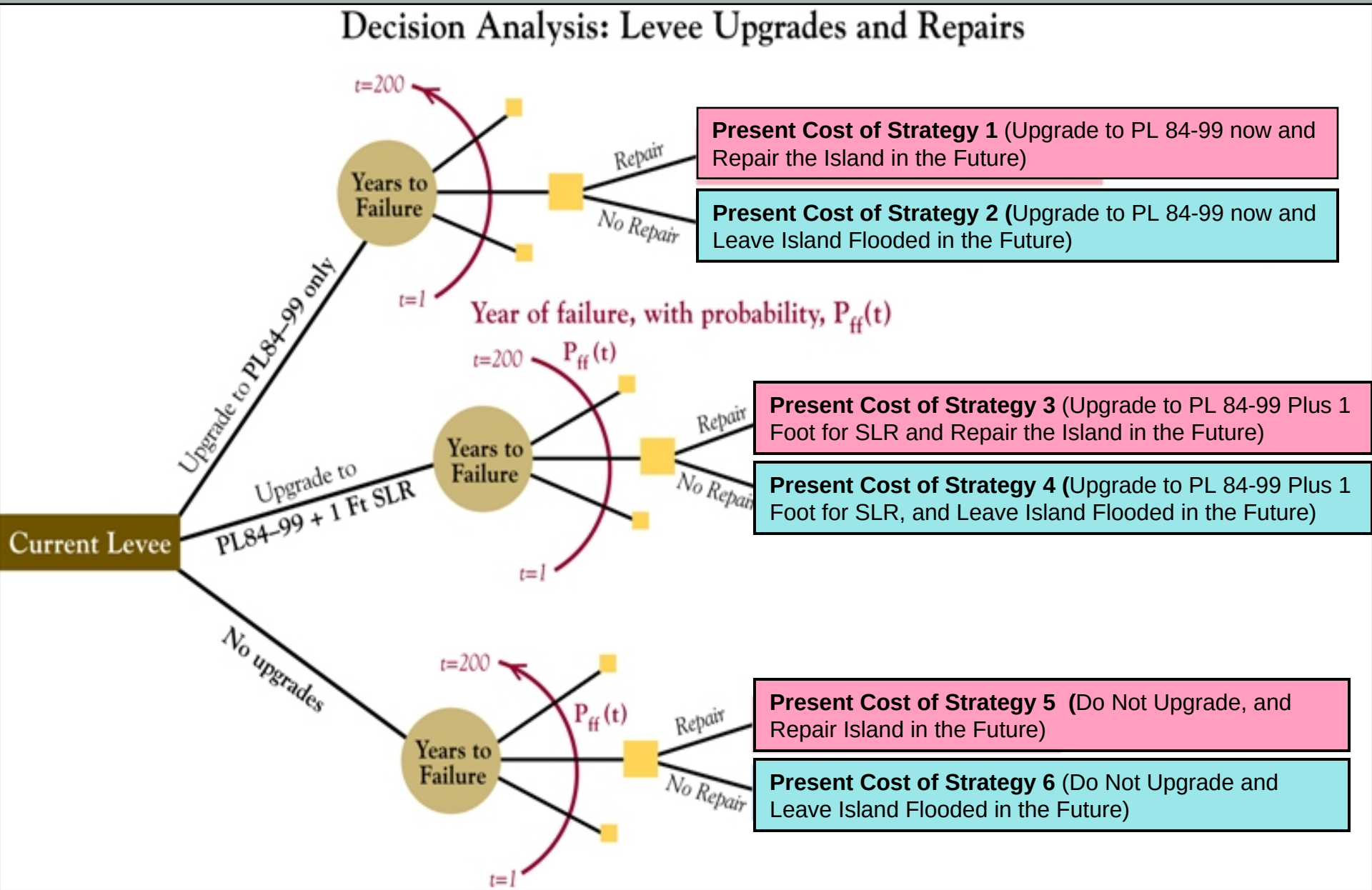


LDAM Methodology - Decision Analysis

"Decision analysis is a logical method to guide benefit-cost comparisons of available decision options when there is uncertainty about their outcomes."

(Lund 2007)

The Decision Tree



Cost of Repairing an Agricultural Island

= Cost of Repair Work & Materials + 1 Year Lost Profits

+ Cost of Recurring Repairs in the Future

– Property Value of the Island

*Will be a “cost” if positive, a “benefit” if negative

Mathematically:

$$\text{Cost} = C_{Repair} + B_k + (C_{Repair} + B_k)(P_f/r) - (B_k/r)$$

C_{repair} = cost of repairing a failure ; B_k = one year of island profits

r = the inflation-corrected interest (discount) rate

P_f = the probability of island failure in any given year

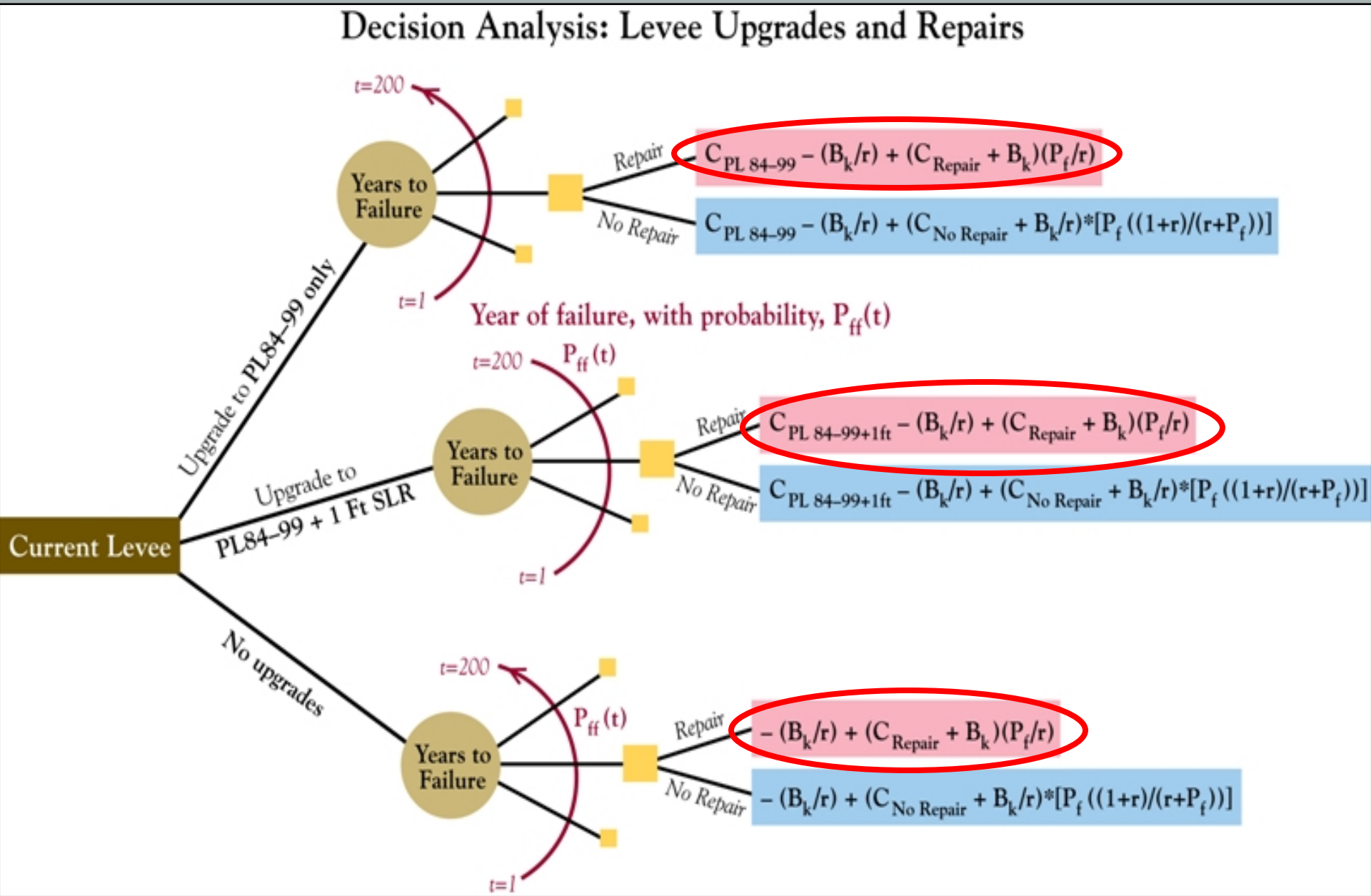
The Cost of Not Repairing an Agricultural Island
(at time of failure)

$C_{NoRepair}$ =

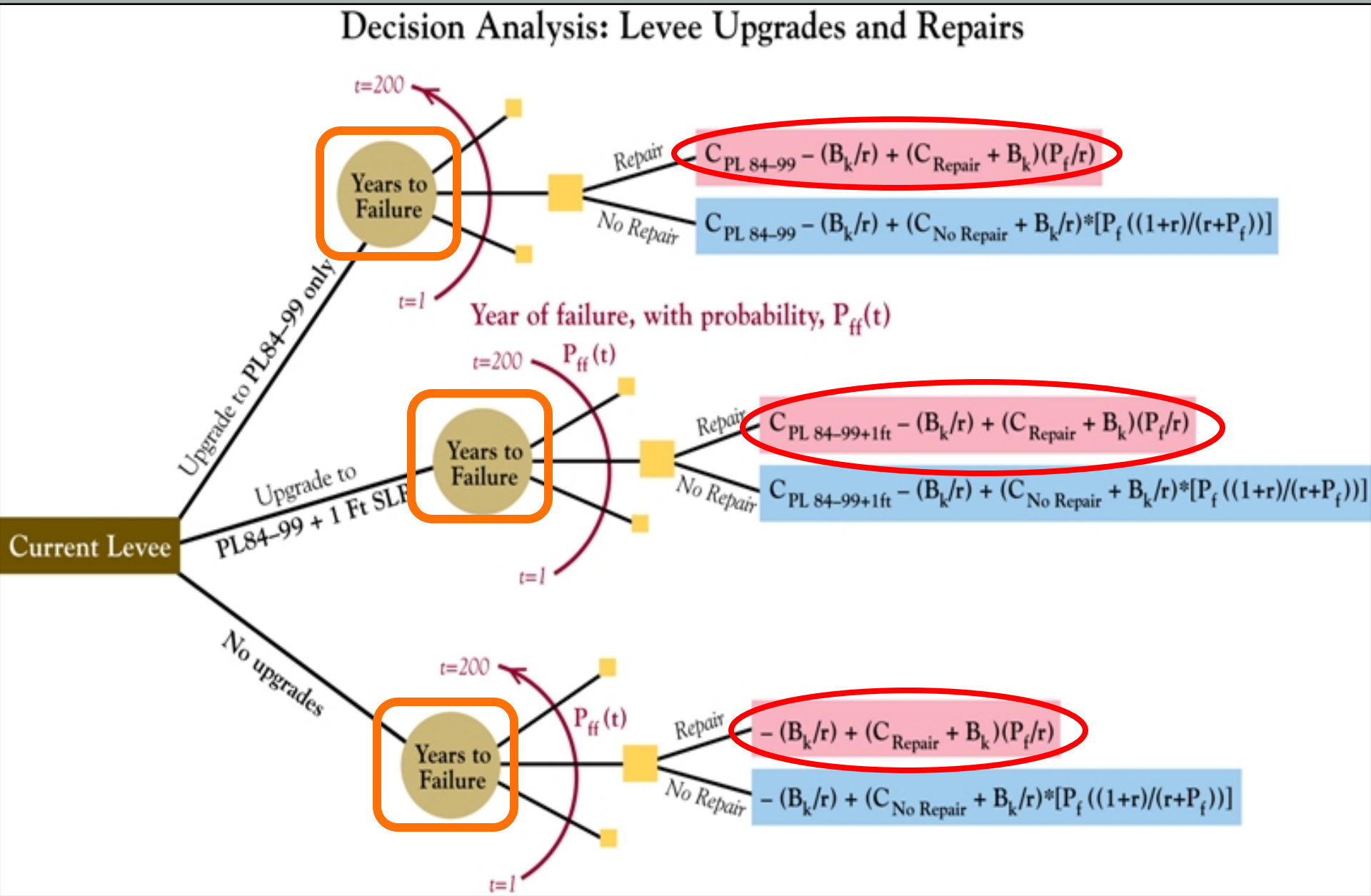
Cost to Reinforce Downwind Islands

+ Cost of Lost Infrastructure

Island Repair Evaluation



Repair Evaluation



Comparing Upgrade Strategies:
(If Island is Repaired in the Future)

Cost = *Upgrade Cost* + Cost of Future Repairs – Property Value

Mathematically:

$$\text{Cost} = C_{upgrade} + (C_{Repair} + B_k)(P_f/r) - (B_k/r)$$

* *"Upgrade Cost" will be absent for the "No Upgrade" strategy*

Model Inputs

Repair Decision:

- Property Values (Assets Included)
- Cost of Repair Efforts
- Infrastructure Costs of Not Repairing a Flooded Island
- Cost of Reinforcing Surrounding Islands

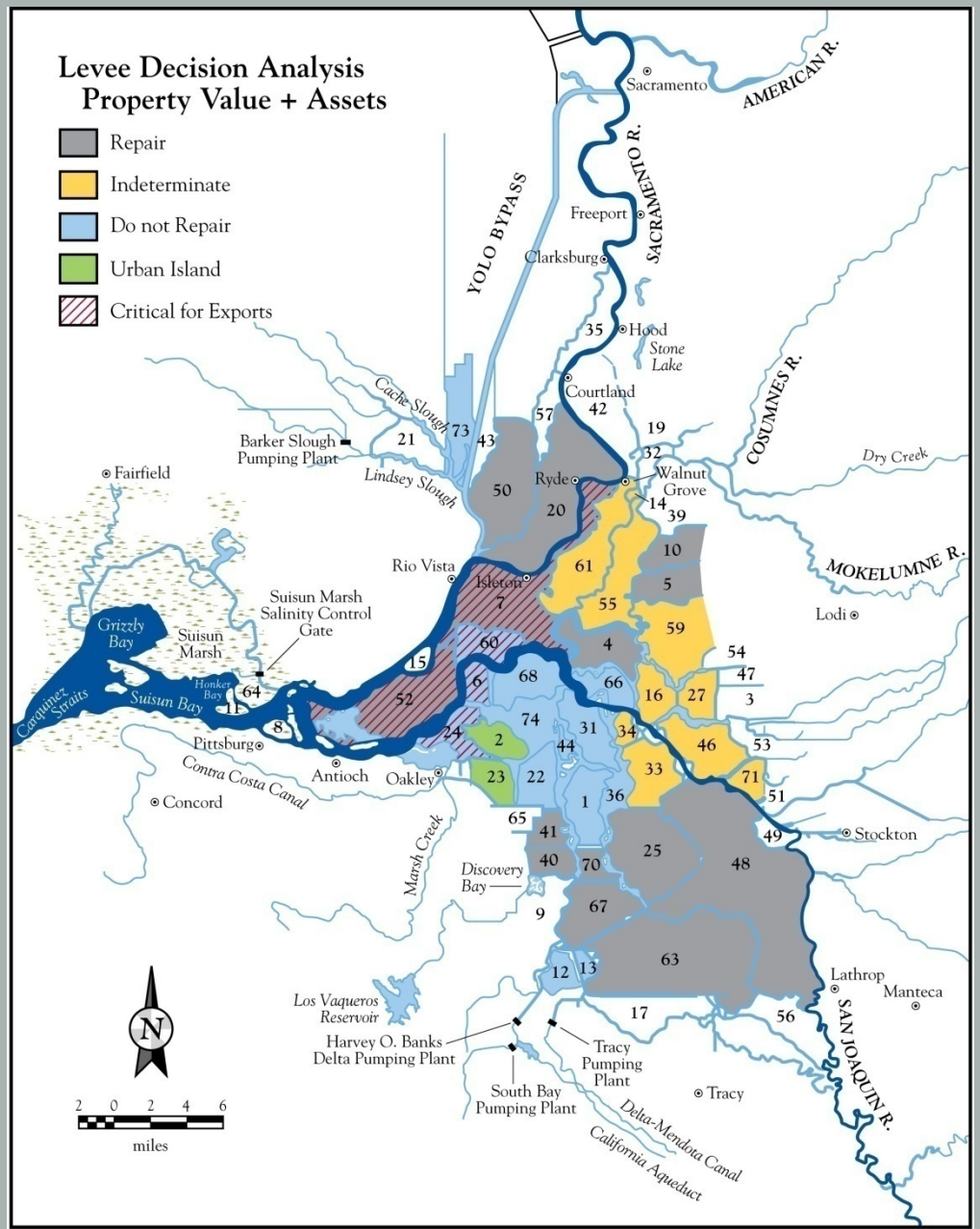
Upgrade Decision:

- Cost of Repair Decision
- Cost of Upgrades
- Probability of Failure for Each Level of Upgrade
- Property Values

Results

10 - 19 islands not economically worth repairing after flooding.

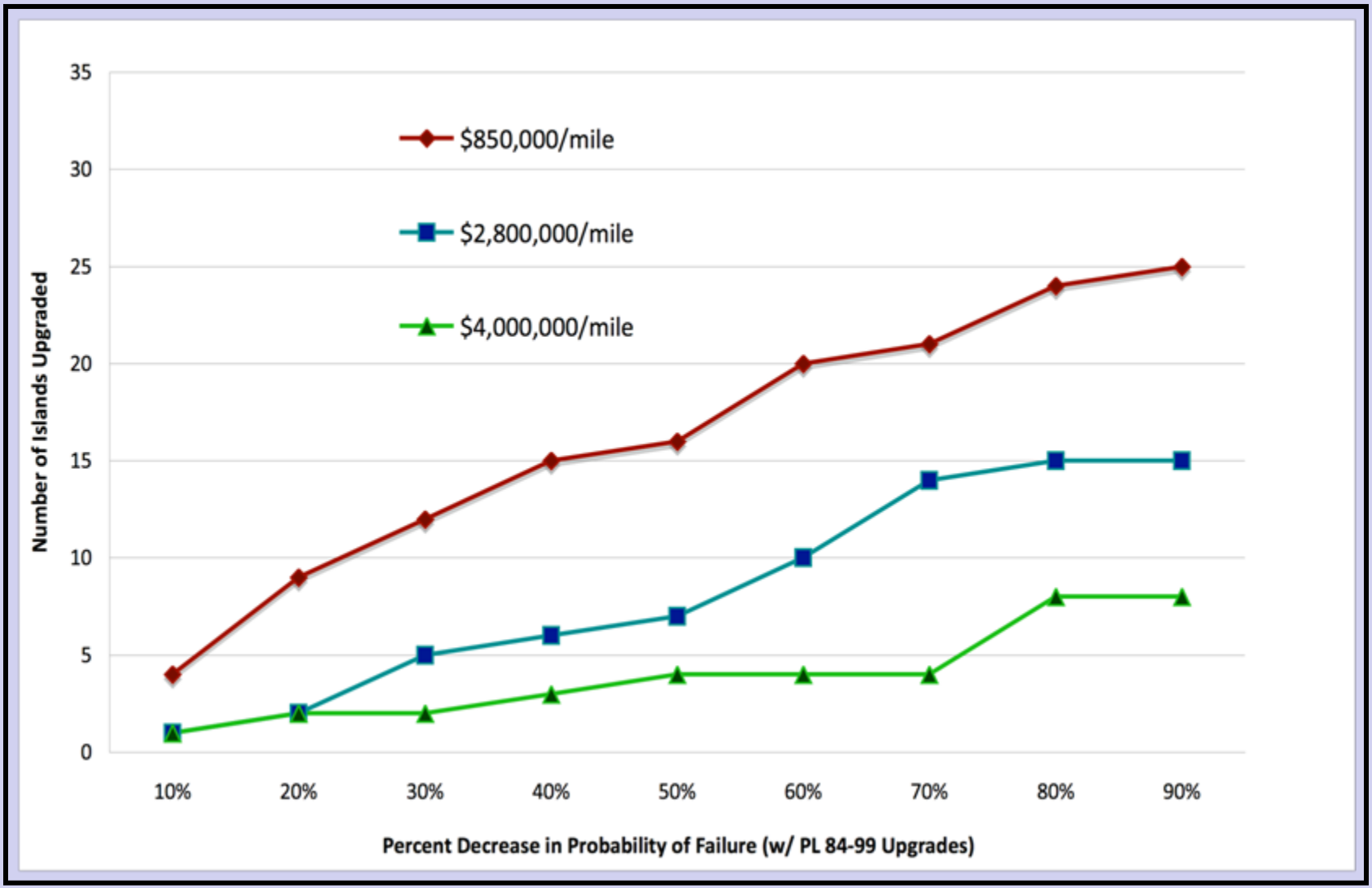
Upgrades not economic for ***any*** of the 34 islands.



Sensitivity Analyses

- What if upgrades were cheaper and/or more effective?
- What if reinforcements to surrounding islands are twice, or three times more costly than we thought?
- What if property values are increased to account for cultural, habitat, or other benefits?

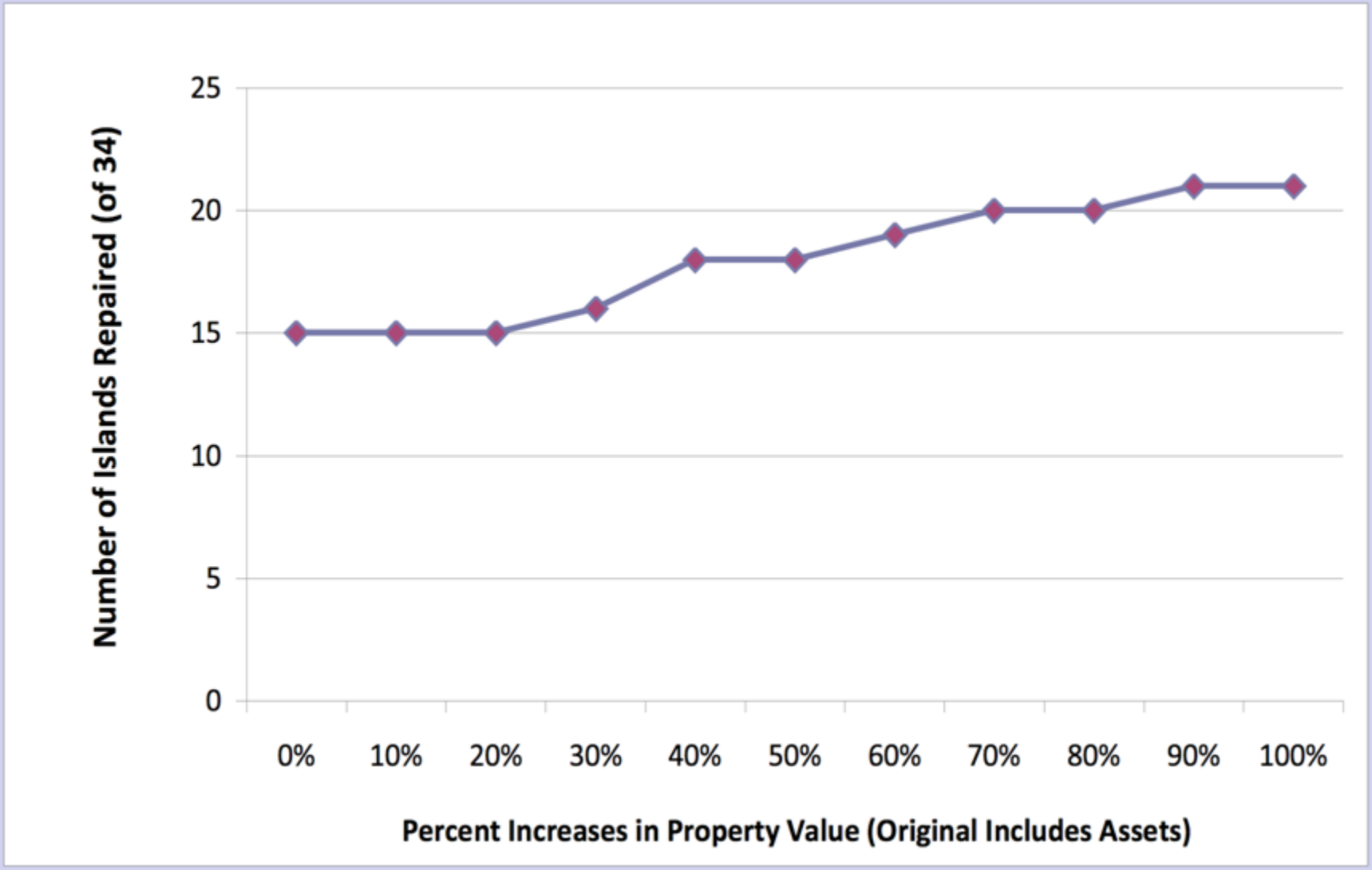
What if Upgrades Are Cheaper and/or More Effective?



What if Reinforcements to Surrounding Islands are More Expensive?

- Increased “no repair” costs in 10 percent increments
- **Doubling** “no repair” costs caused **no change**
- **2** additional islands are repaired after “no repair” costs are **quadrupled**.

What If Island Values Are Higher?



Conclusions

1. **The current Delta landscape seems uneconomical from a statewide perspective.**

Conclusions

2. Selective upgrades and repairs are more economical, and preserves finances for other purposes.

Conclusions

3. Physical and economic drivers will return portions of the Delta to open water.

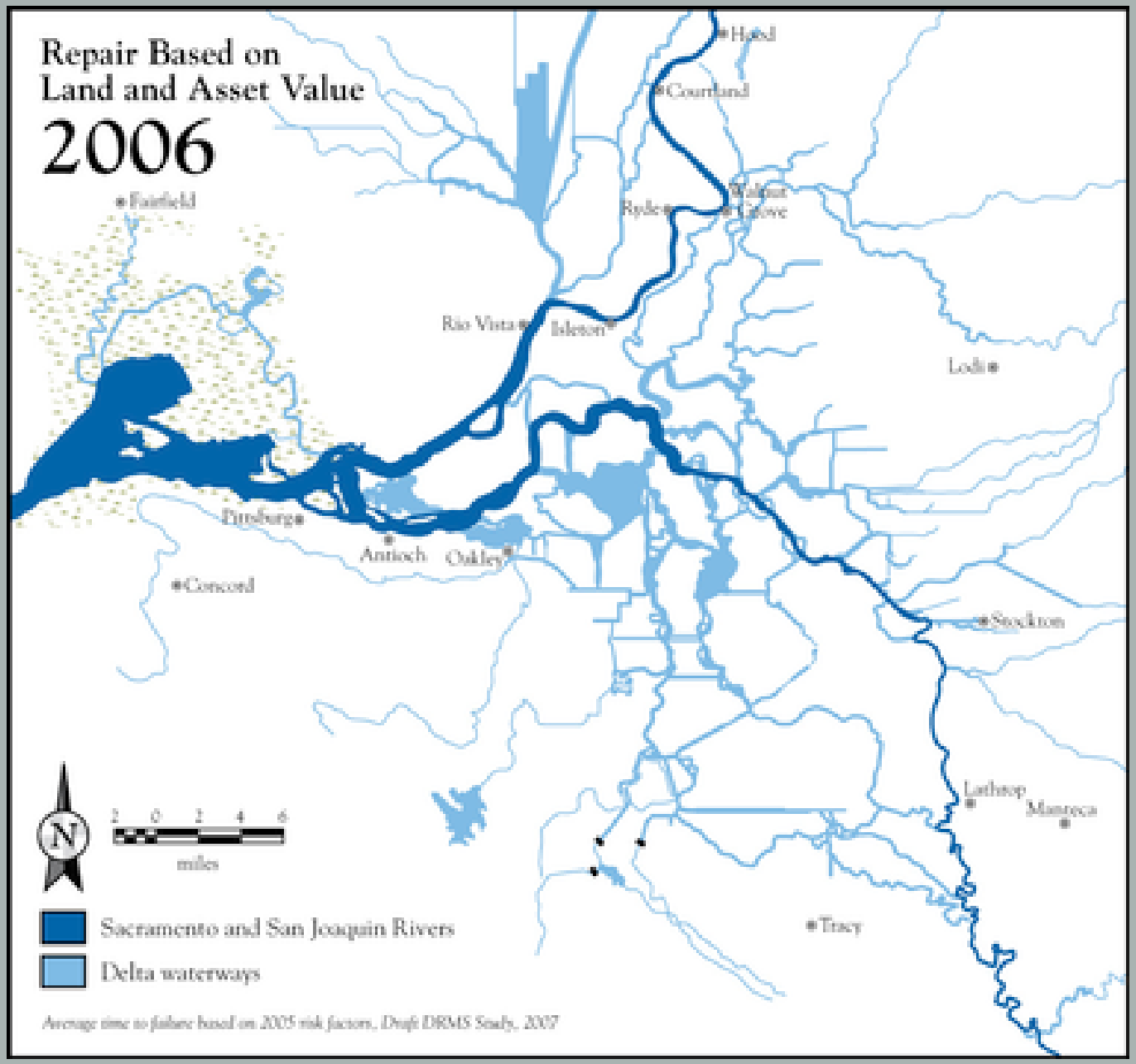
Moving Forward

1. Explore higher island values for cultural worth, recreation and terrestrial habitat.

2. Include changing risk due to sea level rise and subsidence.

3. Explore recreation and habitat values of flooded islands.

4. Water quality / hydrodynamic effects and costs of permanently flooded islands.

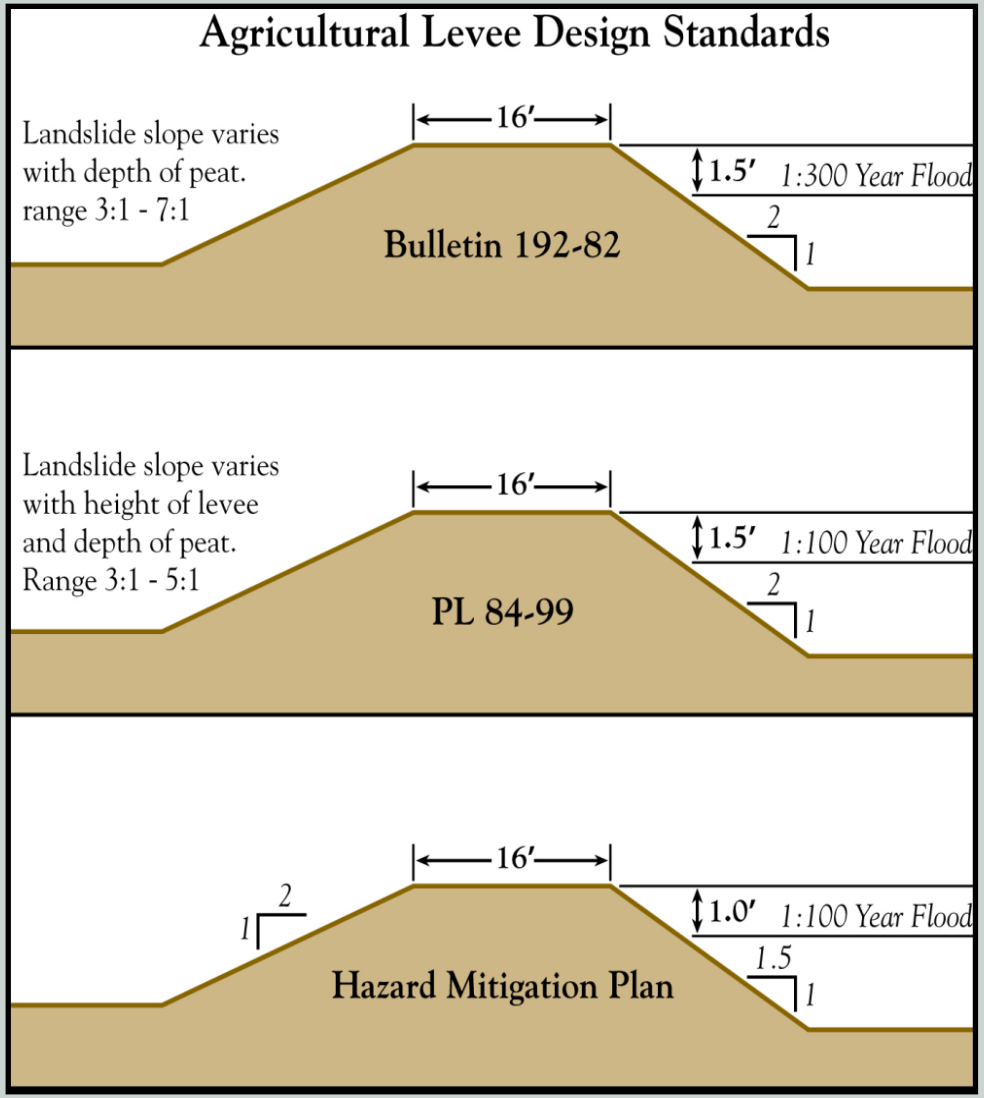

Repair Based on
Land and Asset Value
2006
Hood
Courtland
Walnut Grove
Ryde
Fairfield
Rio Vista
Isleton
Lodi
Pittsburg
Antioch
Oakley
Concord
Stockton
Lathrop
Manteca
Tracy
N
2 0 2 4 6
miles
Sacramento and San Joaquin Rivers
Delta waterways
Average time to failure based on 2005 risk factors, Draft DRMS Study, 2007

Questions?

Source Data

Data Category	Source
Land Uses and Values	Lund et. al 2007, Appendix D
Land and Asset Values	Lund et. al 2007 and DRMS Draft Phase 1 (J.R. Benjamin and Associates, 2007)
Levee Repair Costs and PL 84-99 Upgrade Costs	Communications with Delta levee engineers, and recorded costs for Twitchell, Sherman, and Bouldin
Cost of 1 ft Extra Levee Height for SLR	Communications with Delta levee engineers
Road and Rail Lengths	GIS Tele Atlas' StreetMap Premium Data
Costs of No Repair When Delta Islands Fail	Road and Rail Lengths (from SD_RR), Communications with Delta engineers
Annual Probabilities of Levee Failure	DRMS Draft Phase 1 and Draft Phase 2 (J.R. Benjamin and Associates, 2007)

PL 84-99 Upgrades



- Levee standard set by USACE in 1999
- Joint state-federal effort to involve USACE in non-project levee rehabilitation
- Levees that meet PL 84-99 are eligible for 75% federal, 25% local cost-share arrangements for levee repairs.

Assigning Property Values

1. Property Value: We ran the analysis using two different measures of property value. The first included only land values (easily-transported assets were not included), and the other included an asset estimate (buildings, equipment, infrastructure such as roads and rail lines, etc). Land values were extracted from data assembled in Lund et al., 2007, and asset values were taken from the Draft Delta Risk Management Strategy Phase 1 Report (J.R. Benjamin and Associates, 2007).

Repair Costs

An average cost of **$25 million dollars was assumed to repair a breach and pump water from the island**, based on interviews with engineers familiar with the Delta who estimated that the typical levee breach repair costs $20 to 30 million. To repair the breached levee perimeter, we assumed $5 per yard for on-island replacement fill, $15 per yard for off-island fill, 20 percent per yard engineering costs, and $15 per yard for replacing rip rap. These materials costs were also developed from estimates provided in interviews with Delta engineers.

Costs of PL 84-99 Upgrades

These costs were calculated assuming **$2.8 million dollars per mile of levee. This figure was based on evaluation of a range of PL 84-99 upgrade costs taken from multiple islands, including Twitchell, Sherman, Bouldin, and King**, based on communication with levee engineers and DWR engineers. This value is close to that cited by DRMS for upgrades. Also, we noted which islands have already partially undergone PL 84-99 upgrades, and subtracted the appropriate amount from their estimated upgrade costs.

Costs of PL 84-99 + 1ft

These were calculated by taking the lengths of each island's levees and**applying a geometric formula for increased cut volumes needed to raise the island levee one foot, in keeping with PL 84-99 geometric standards. Levee lengths were obtained from GIS data derived from DWR, cited in Mount and Twiss (2005).**

Once we calculated the volume of material needed, we assigned the following costs:**$10 per cubic yard for fill and 1.4 cut cubic yards per cubic yard**. These values were **obtained from interviews with Delta engineers**. We assigned no costs for engineers and contractors because in our analysis, we assume that such extra upgrades would occur at the same time as the PL 84-99 upgrade, for which engineering costs have already been included.

Infrastructure Costs for a Flooded Island

i. Cost estimates for rebuilding roads, highways, or railroads are based on a simple, per mile cost obtained from the DRMS Preliminary Strategies Report Section 12, which reports an estimated **cost of $45 million per mile of seismically resistant levee. Levees of this caliber would have to be built to support the roads or highways on top of them**

ii. The length of roads and railroads on each island used in the assessment of seismically resistant levee needs (above) were obtained from GIS Tele Atlas StreetMap Premium data

Cost of Reinforcing Surrounding Islands

calculated with these assumptions:

i. The approximate length of levee upgrades needed for these surrounding islands should equal roughly half the circumference of the failed island (geometrically).

ii. **The surrounding levees need to be raised 1 foot to account for this increased exposure**.

iii. **Cost of these upgrades should thus be equal to *half* the cost of materials for raising the levee of the failed island by one foot** (obtained from earlier calculations of PL 84-99 + 1 ft SLR costs).

iv. **A multiplier of 1.3 is assigned to account for 20 percent cost for engineers and construction management, along with 10 percent state costs for management and processing.**

Assigning Probabilities

For our probabilities of failure in the case of no upgrades, we use the latest **Draft DRMS Levee Optimization Assessment** (J.R. Benjamin and Associates, 2008). **Based on interviews with government and private levee experts, we then assumed a 10 percent decrease in probability of failure for that island, with each level of upgrade.**

zone	NAME	*Flood*	*Seismic*	*Flood + Seismic*	*Flood PL 84-99*
Central	Bacon Island	0.04	0.02	0.06	0.04
Central	Bouldin Island	0.06	0.03	0.09	0.05
Central	Empire Tract	0.04	0.02	0.06	0.04
Central	Mandeville Is.	0.04	0.03	0.07	0.04
Central	McDonald	0.02	0.03	0.05	0.02
Central	Medford Is.	0.03	0.02	0.05	0.03
Central	Quimby Island	0.04	0.03	0.07	0.04
Central	Rindge Tract	0.01	0.02	0.03	0.01
Central	Venice Island	0.07	0.04	0.11	0.06